theme of his address to the Midland Institute at Birmingham, and, we have no doubt, charmed his audience with his manner and ready wit. But what is there in either of the lectures just mentioned that throws the slightest light on the real difficulties of the subject? Why was not Sir F. Bramwell moved to read a paper at the meeting of the British Association which took place a few weeks ago in the very building in which he addressed the Midland Institute? Had such a paper been read, a most interesting and animated discussion would have arisen, and the nation would have had the advantage of learning the opinions of men who have devoted their lives to working out the problems connected with the theory as well as the practice of the construction of ordnance. We are driven to the conclusion that the Ordnance Committee considered that such a course would have been dangerous to their self-respect; the deplorable ignorance which characterises all attempts at working out difficult questions by Committees would have been too glaringly exposed; it was much safer not to subject themselves to cross-examination.

If we are wrong, if the Committee have complete answers to the questions raised, it is open to them to convince the nation of the fact, because the sessions of the Institution of Civil Engineers will very soon commence, and some member of the Ordnance Committee should be deputed to read, not a popular lecture, but a serious paper that will demonstrate to a roomful of practical engineers that our guns have been constructed according to the rules which guide engineers in their ordinary work, and that yet they have failed. We have small hopes that the challenge will be accepted.

THE MATHEMATICAL AND PHYSICAL SCIENCES

Histoire des Sciences Mathématiques et Physiques. Par M. Maximilien Marie. Tomes I.-IX. (Paris: Gauthier-Villars, 1883-86.)

M. MARIE'S great work advances rapidly towards completion. The first three volumes appeared in 1883; the concluding three are in the press; we have now before us nine volumes, bringing down the narrative from the time of Thales to the time of Laplace. The undertaking is a vast one; and we are not surprised to hear that it has cost forty years of preparation. The learned world is to be congratulated that it has fallen into such able hands. M. Marie combines, in a rare degree, scientific with literary qualifications. A certain grace and poignancy of style set off his wide erudition and practical acquaintance with methods of teaching. He can be vivacious even over processes of integration. The accumulated mass of his materials nowhere hinders the lightness of his tread. Keen touches of sarcasm enliven his most abstruse expositions, and agreeably remind his readers that a sense of humour may subsist concurrently with a thorough mastery of the higher analysis.

He has accordingly produced a book which, with these merits and some corresponding defects, only a Frenchman could have written—one eminently interesting and original, at once lively and profound, instructive throughout if occasionally one-sided, frankly displaying the prepossessions of its author, and not unfrequently—as we shall presently show his heedlessness of historical and biographical accuracy. Its characteristic merit consists in the lucid interpretations contained in it of the older methods of mathematical research. The works of ancient and mediæval geometers are analysed, not barely in the view of exhibiting the results attained by them, but with the further purpose, most completely realised, of rendering their various artifices and modes of working intelligible to the least skilled in the archæology of mathematics. M. Marie's is indeed in no sense a book for beginners. It presupposes a considerable acquaintance with the most recent developments of analysis. The reader thus provided may, however, follow with ease and pleasure the steps by which earlier inquirers advanced; he may enter into their conceptions, place himself at their precise point of view, and while marvelling at the ingenuity which carried them so far, study the limitations of thought which hindered them from proceeding any farther. He may learn how the singular deficiency in the idea of abstract number which hampered the workings of such luminous and powerful minds as those of Archimedes, Apollonius, and Euclid, was supplied from the far East; how Hindu algebra and arithmetic formed the complement of Greek geometry; how both were transmitted through Arabic channels to Italy, and together constituted the starting-point of modern discoveries. Nor is it less curious to watch the gradual emergence of ideas big with the progress of the future, such as those of negative and imaginary, or infinitely small quantities; how they presented themselves with hesitation, and were at first shunned and distrusted; how they grew bolder and insisted on recognition; how their tentative and partial treatment became widened and generalised until they finally developed the whole extent of their capabilities.

It is well known that Archimedes gave the first approximation to the value of π; but the occasion and significance of the step are often lost sight of. It marked, with the almost simultaneous attempt of Aristarchus of Samos to measure the relative distances from the earth of the sun and moon, the introduction of numerical calculation into theoretical researches (Marie, t. i. p. 59). The novel effort was prompted, in each case, by the interest of a special problem. Archimedes, naïvely enough, sought to prove that the idea of infinity had its root in enumerative impotence, and could be abolished by expanding the resources of arithmetic. He exemplified his contention by computing the number of grains of sand contained in a sphere with the interval from earth to sun for its radius. But a preliminary valuation of the ratio between the circumference of a circle and its diameter was indispensable; and the tract on the "Dimension of the Circle" was accordingly, in M. Marie's plausible view, written as a kind of preface to the "Arenarius." Incidentally to the calculations in the latter treatise, he perfected the Greek system of numeration, and foreshadowed the principle of logarithms.

M. Marie has ventured a kind of restoration of the "algebra" of Archimedes (t. i. p. 262). His remarks on this disputed subject are of great interest. He holds it impossible that his inventions should have been reached by the arduous path of his demonstrations; and ascribes to him, accordingly, the possession of a compendious method of reasoning founded on the transformation of ratios, conducting easily to results otherwise unattainable even by his transcendent genius. The secrecy observed regarding it may have been due, in part to the difficulty of setting it forth in the absence of a suitable algorithm, in part to the conventional prevalence of the synthetic mode of exposition. The art was doubtless held in common with Apollonius, and other geometers of the time; but was treated as a mere rude tool, not worth the labour of bringing to a higher perfection. Had this early analysis been independently cultivated, and set free from its servitude to geometry, the "method of exhaustions" must, by its aid, in our author's opinion, have given birth to the Calculus eighteen hundred years before Cavalieri thought of his "infinitesimals."

The work before us aims, above all, at developing, as a coherent whole, the logical sequence of ideas. It would be unfair to say that this aim has been missed; yet we cannot help thinking that it might have been more perfectly attained. A vivid light, it is true, is frequently thrown upon obscure passages of research, and the filiation and significance of discoveries are, here and there, brought out with uncommon sagacity. Nevertheless, there is something wanting which M. Marie could easily have supplied.

A somewhat fragmentary plan has governed the composition of the book. The twenty-four centuries embraced by it are divided into sixteen periods of very unequal length, treated each in a section apart, consisting of a prefatory sketch of the progress accomplished during its course, followed by a series of biographies of those who contributed towards it, arranged in strict chronological order. Chemists and mathematicians, astronomers and botanists, mechanicians and physiologists, are thus placed side by side, with no closer tie of connection than the successive occurrence of the years of their birth. We have no sooner done with Lagrange's Calculus of Functions than we are confronted with Watt's transformation of Newcomen's steam-engine; the convulsions of Galvani's memorable frog succeed; and we pass thence to Parmentier's triumphant growth of potatoes on the plain of the Sablons,—all subjects of great interest, and treated with singular charm. Yet their variety, if it form, in a certain sense, an attraction, demands a stronger bond of unity than is here afforded. The true historical element, in short, is deficient. Nor is the want satisfactorily supplied by M. Marie's sixteen prefaces. We should be sorry to lose them; but they do not suffice. The absence of a connected narrative is still sensibly felt. Even if its design had otherwise remained unchanged, the book might at least have been provided with a general introduction, delineating and characterising the course of events to be detailed, pointing out the confluence, at epochs of discovery, of various and distant streams of thought, and presenting, in one luminous view, the progress in exact knowledge made by our race from the first dawn of civilisation until now. Perhaps it may not even yet be too late to add to a most valuable work a supplementary volume which would go far towards rendering it complete.

In another direction, M. Marie has perhaps unduly extended the scope of his enterprise. To have treated adequately the history of *all* the sciences, natural as well as mathematical, would have demanded, not a dozen, but fifty volumes. Yet all are nominally included in his scheme, while, in point of fact, those branches of knowledge remote from his principal theme receive only the casual attention of some stray jottings, with biographical notices of their leading promoters.

His choice of representative names, too, is open to criticism. Among omissions, that of Adelard of Bath, the first translator of the "Elements of Euclid" from the Arabic, is very remarkable. He was one of the most effective popularisers of Arab science in the thirteenth century, and played no unimportant part in the revival of mathematical learning. Yet he is not only ignored by M. Marie, but his version of Euclid is handed over to Campanus of Novara, with whose commentary it was published at Venice in 1482, and who has in consequence frequently gained the credit of its execution.

Nor should the unfortunate Cecco d'Ascoli have been altogether forgotten. His "Acerba," if not all that it has been claimed to be, contains many striking intuitions of natural truths. M. Marie, however, takes little interest in the premonitory symptoms of discovery; and the rage for unearthing its obscure anticipations has possibly been carried a little too far. We miss, further, the name of Giambattista della Porta, the *effective* inventor of the camera obscura, whose "Magia Naturalis" was of European fame and influence. And William Cullen, the founder of rational chemistry in Great Britain, was at least as well worthy of notice as Kunckel, known in connection with the manufactures of ruby glass and of phosphorus, to whom just three times the space is allotted as to Black, the discoverer of "fixed air," and of "latent heat."

A crowd of superfluous names, on the other hand, might be cited. It seems ungracious to object to the presence of a sketch so interesting in itself as that of the career of Ambroise Paré; yet it is not easy to see what the treatment of gunshot wounds has to do with the history of mathematical or physical science. Equally outside the proper scope of its cognisance are Henkel's improvement of Dresden china, Bosc d'Antic's contributions to the art of glass-making, Perronnet's bridges, Trudaine's "superb" highways, and Vaucanson's automata. If these give a valid title to admittance, why exclude Hargraves, Arkwright, Smeaton, MacAdam, and a host besides? Why should the spinning-jenny be passed over in silence, when Loriot's ribbon-loom comes in for honourable mention? In truth, however, industrial and mechanical inventions belong elsewhere.

It remains that we should justify our hint that M. Marie's facts and dates occasionally stand in need of revision. A perusal of Prowe's "Life of Copernicus" would have obviated several inaccuracies in his brief account of the reformer of astronomy. The intention of Copernicus to embrace the ecclesiastical state was not superseded, even momentarily, by his journey to Italy; on the contrary, he received his appointment as Canon of Frauenburg in 1497, shortly after he had entered the University—not of Padua, as stated by M. Marie, but of Bologna. Nor was he ordained a priest at Cracow in 1501. He took minor orders on entering the Chapter, but never became a priest; and his sojourn in Italy was unbroken between 1501 and 1505. Moreover, his doctoral degree (not in medicine, but in canon law) was conferred at Ferrara, May 31, 1503. He sought no diploma at Padua, though he studied medicine there during the four years of his *second* stay in Italy. The assertion that at the age of twenty-seven he was summoned to profess mathematics at Rome is inexact. Uninvited, so far as is known, he repaired thither with his brother early in the year of jubilee (1500); and delivered unofficially some brilliantly-attended lectures during the ensuing winter. Finally, he settled down to his life's work at Frauenburg, not in 1510, but in 1512.

One rubs one's eyes in amazement to find Basil Montagu's discredited and superseded edition quoted as the best and completest of Bacon's Works. Is it really possible that the news of the late Mr. Spedding's labours has not yet reached Chantilly? It would appear not; for his name is unmentioned by M. Marie, who equally overlooks Mr. Fowler's instructive edition of the "Novum Organum."

In the date assigned for Robert Hooke's death, he copies an error of Poggendorff's, who states that he died at the age of eighty-seven, whereas he did not live to complete his sixty-eighth year. The substitution of 1722 for 1703 is of more than simply formal importance, since the publication of Newton's "Optics" and his acceptance of the Presidentship of the Royal Society, both depended upon the event thus post-dated. Newton loathed controversies, although drawn into many. But while Hooke lived, they could only be avoided by self-effacement; and this was accordingly the policy adopted, as far as possible, by his great rival.

M. Marie makes no secret of his aversion to the sour little professor of Gresham College; and it is too true that his character repels sympathy, while his achievements were not of the dazzling sort to blind men to his failings. Still, his claim to due recognition remains intact, although ignored by our author, who states openly that only Poggendorff's eulogies, by "forcing his hand," frustrated his intention of punishing his egotism with neglect. Yet Hooke, by Newton's express admission, discovered independently the law of inverse squares, and it is not too much to say that, but for his incitements, Newton would not have undertaken the investigation which led to his immortal discoveries.

M. Marie's grudge against Hooke does not seriously detract from the value of his work; but it is otherwise with his ill-will towards Newton. Not only is he avowedly the partisan of Leibnitz in the never-ending debate concerning the invention of the Calculus; but his dislike (not wholly unjustifiable) to Newton's conduct in the matter extends to all the processes of his mind. He compels himself, it is true, to utter a few obligatory words in acknowledgment of the greatness of his work; but its entire significance seems to escape him. His readers are only quite casually reminded that the discovery of the system of the world was of greater moment in the history of science than the solution of the problems of the brachystochrone, or of the centre of oscillation.

We are told by M. Marie that Newton represented his University in Parliament from 1688 until 1705, during which time he was assiduous in his attendance, but spoke once only, to request the usher to shut a window (t. v. p. 170). In fact he sat three (1689-90, and again 1703-5), not seventeen, years. At p. 162 of the same volume we meet the surprising statement that Halley predicted for 1682 the return of the comet observed by Kepler in 1607. It is almost superfluous to remark that its appearance in 1682 was as unlooked-for as that of any of its predecessors, that its periodical character was then first divined, and in 1759 verified.

The observation made by Wilcke in 1787 that the auroral corona forms in the magnetic zenith is attributed by our author to De Mairan in 1747. The eminent Academician, we can assure him, would have been the last to welcome a remark so subversive of the arguments by which he sought to efface the magnetic character of the phenomenon. Neither is it the case that Halley noticed the bisection of the auroral arch by the magnetic meridian. Obvious though the coincidence appear, it was first pointed out by Ussher in 1788.

We note further M. Marie's curious incredulity as to the authentic measurement, so far, of the parallax of any single star; his statements that the accepted value of the solar parallax is 8″·5 (t. ix. p. 43), that the mass of the moon is $\frac{1}{88}$ that of the earth, and that Herschel detected interstitial movements in resolvable nebulæ (t. ix. p. 145); finally, his ascription to Sir *William* Herschel of the translation of Lacroix' "Differential Calculus" executed by his son conjointly with Babbage and Peacock.

These and other similar blemishes, however, are very far outweighed by the merits of the work in which they occur. It is one of marked individuality; and individuality lends interest, if it sometimes begets defects. No student of the higher mathematics should leave it unread; its perusal cannot fail to afford pleasure, as well as to widen comprehension of modern methods by their comparison with those they have succeeded, and by the intelligent survey of their growth in the past.

CHEMISTRY OF WHEAT, FLOUR, AND BREAD

Chemistry of Wheat, Flour, and Bread, and Technology of Bread-making. By William Jago. (Brighton: Published by the Author, 1886.)

THIS bulky volume professes to treat of its subjects in an exhaustive manner. Wheat, flour, and bread-making are as important as they are universal; and if they are common-place, their study requires deep insight into chemical science. Mr. Jago's book will form a valuable addition to economic science. The composition of wheats from all parts of the world, the minute structure of the grain, the composition of milling products, and the processes of panary fermentation, fall properly within the limits of such a work, and are dealt with in an exceedingly painstaking manner. The various methods of bread-making, the chemistry of the art, and the effects of blending different descriptions of wheat so as to secure the best possible results, are amply and ably discussed. Modern milling and baking appliances are also described carefully and illustrated graphically. There is likewise enough of the author's own thought and research to redeem the work from the stigma of being mere compilation. The book is decidedly useful, and, making due allowance for the progressive state of our knowledge upon many of the topics dealt with, it will probably be received as a standard work. It brings within its ample limits a vast